2.10 Geology/Soils/Seismicity/Topography

2.10.1 Regulatory Setting

For geologic and topographic features, the key federal law is the Historic Sites Act of 1935, which establishes a national registry of natural landmarks and protects "outstanding examples of major geological features." Topographic and geologic features are also protected under the California Environmental Quality Act.

This section also discusses geology, soils, and seismic concerns as they relate to public safety and project design. Earthquakes are prime considerations in the design and retrofit of structures. The Department's Office of Earthquake Engineering is responsible for assessing the seismic hazard for Department projects. The current policy is to use the anticipated Maximum Credible Earthquake (MCE), from young faults in and near California. The MCE is defined as the largest earthquake that can be expected to occur on a fault over a particular period of time.

2.10.1.1 City of San Clemente General Plan (May 1993 – Updated through May 2003)

The City of San Clemente General Plan has proposed the following applicable goals, objectives, and policies to reduce the risk in the community from geological hazards:

Goal: Ensure that non-seismic (geologic and soils) and seismic hazards potentially affecting areas for human use or habitation are properly mitigated or avoided prior to development.

Strong Seismic Ground Shaking Objective 12.2: Protect health and life safety, and reduce the level of potential property damage from the adverse effects of strong seismic ground shaking by implementing effective standards for seismic design of structures in the City of San Clemente, consistent with the state-of-the-art; and facilitate rapid physical and economic recovery following a damaging earthquake.

> **Liquefaction Policy 12.3.1:** Require, in conjunction with proposed development, the determination of the liquefaction potential at sites generally located and depicted on Figure 12-1 of the City of San Clemente General Plan, as liquefaction areas or potential liquefaction areas, and require that specific measures be taken, as necessary, to prevent or reduce damage in a seismic event especially to essential lifelines.

Liquefaction Policy 12.3.2: Promote the collection and compilation of the most current data on groundwater levels and liquefaction susceptibility. The information should be used as a basis for identification of areas susceptible to liquefaction, and for modification, as necessary, of liquefaction-related policies or procedures.

Liquefaction Policy 12.3.3: Encourage the development of a means to identify and reduce the liquefaction potential of sites when structures currently exist.

Slope Stability, Landslides, and Soils Objective 12.4: Protect life, provide safety, and substantially reduce the potential level of property damage from landslides, mudflows, slope failures and soil hazards; promote the collection and utilization of more complete information on slope instability potential throughout the City of San Clemente.

Slope Stability, Landslides, and Soils Policy 12.4.1: Require, in conjunction with a proposed development project, the determination of landslide and slope instability potential and that pertinent measures be incorporated in the project design to mitigate this potential.

Slope Stability, Landslides, and Soils Policy 12.4.3: Evaluate in conjunction with proposed development all slopes with a greater than 25 percent grade for slope stability and erosion potential, include slopes less than 25 percent where liquefaction (lateral spreading) potential exists.

2.10.1.2 City of Dana Point General Plan (July 1991)

The City of Dana Point has proposed the following applicable goals and policies to reduce the risk in the community from geological hazards in the City of Dana Point General Plan:

Goal 1: Reduce the risk to the community from geologic hazards including bluff instability, seismic hazards and coastal erosion.

Policy 1.3: Adopt standards and requirements for grading and construction to mitigate the potential for bluff failure and seismic hazards.

2.10.1.3 City of San Juan Capistrano General Plan (November 2001)

The City of San Juan Capistrano General Plan identifies future development regulations for transportation arteries and requires detailed field and laboratory testing to establish the “survivability design and engineering requirements” for the proposed project. The activities to be undertaken for projects located in the City of San Juan Capistrano include:

- Site-detailed geologic mapping and boring to determine that surface faulting and ground breakage has not occurred and is unlikely to occur in the future. Trenching is not an acceptable method for determining geologic conditions because of its adverse environmental effects.
- Adequate boring and field laboratory testing to determine accurately the subsurface profile and the static/dynamic properties of soil and rock materials.
- Calculation of design response spectra, based on repetition and structural properties (damping and ductility).
- Thorough inspection of the construction to ensure that designs are in compliance with the City of San Juan Capistrano's General Plan provisions, including a written certification by the contractor that all work has been done in strict accordance with plans and specifications.
- Periodic inspection of all structures and systems to determine that no detrimental modifications have been made, and that proper maintenance has been provided.

2.10.2 Affected Environment

This section is based on the Preliminary Geotechnical Design Report (Preliminary GDR, April 2010 [Revised June 2010]), the General Plans for the Cities of San Clemente, Dana Point, and San Juan Capistrano, and Structure Preliminary Geotechnical Reports (SPGRs, January 2010). The Preliminary GDR is on file and available for review at the Department District 12 office. Regional geology is shown in Figure 2.10-1.

2.10.2.1 Topography

The north portion of the project alignment trends roughly northeast to southwest. The central and southern portion of the project alignment trends parallel to the Pacific Coast along the coastal plain. Topographic elevations range from 98 ft to 112 ft amsl.

Most of the slopes adjacent to I-5 are less than 50 ft in height with slope gradients that do not exceed a 2:1 horizontal/vertical ratio (H:V), with the exception of slopes near Avenida Pico on the northbound side of the freeway, where slopes are greater than 80 ft in height with slope ratios of 1.5:1 (H:V) or less.

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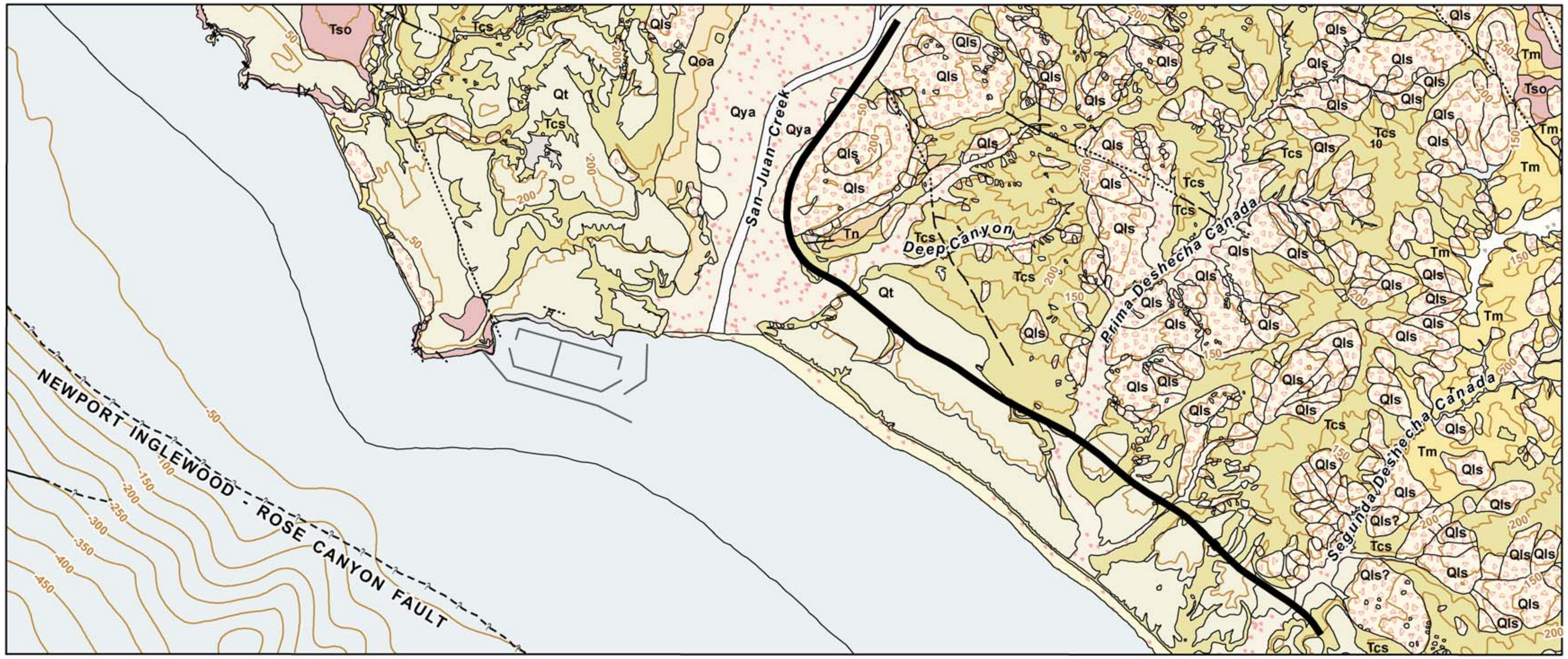

Explanation of Geologic Map Units and Symbols

- I-5 HOV Lane Extension Limits
- Approximate contact between geologic units
- Fault, solid where accurately located
- Fault, dashed where approximately located
- Fault, dotted where concealed
- Fault, dashed, queried where inferred, questionable
- Topographic contour; 50 m interval
- 10 Strike and dip of bedding
- Qw Wash deposits
- Qls Landslide deposits, undivided
- Qls? Landslide deposits, queried where questionable
- Qmb Marine beach deposits
- Qyf Young alluvial fan deposits
- Qya Young alluvial flood plain deposits
- Qyc Young colluvial deposits
- Qoa Old alluvial flood plain deposits
- Qt Non-marine and marine terrace deposits
- Tn Niguel Formation
- Tcs Capistrano Formation, siltstone facies
- Tct Capistrano Formation, turbidite facies
- Tm Monterey Formation
- Tso/Tsoss San Onofre Breccia; breccia and sandstone
- Tsa Santiago Formation

Adapted from: Kennedy and Tan, 2005, Geologic Map of the Oceanside 30' x 60' Quadrangle, California: California Geological Survey, Regional Geologic Map No. 2, scale 1:100,000

LSA

FIGURE 2.10-1

N

0 2250 4500

FEET

SOURCE: Kleinfelder

I-5 HOV Lane Extension

Regional Geology

12-ORA-5 PM 3.0/8.7

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2.10.2.2 Regional Geology

The study area is located in a coastal terrace subzone of the Peninsular Ranges Geomorphic Province of Southern California and consists of Cretacaceous age igneous rocks of Southern California Batholith and various Jurassic age metamorphic rocks. Igneous and metamorphic rocks underly central and eastern Orange County and along the axis of the Santa Ana Mountains.

The coastal terrace subzone is underlain by Pliocene to middle Miocene age marine and nonmarine sedimentary rock comprised primarily of sandstone, siltstone, claystone, and shale, and lesser amounts of limestone, conglomerate, and breccia. The sandstone layers are generally more resistant to erosion, forming steep prominent hillsides. The generally weak and less resistant siltstone, shale, and claystone units form gently rolling hills.

In addition, the gradual emergence of the continental shelf resulted in the development of several wave-cut coastal terraces within the study area. These coastal terraces consist of relatively thin marine and terrestrial deposits. Sea level has continually risen following the end of the Pleistocene era, resulting in filling of alluvium within the coastal drainage system.

2.10.2.3 Soil Conditions

Types of soils underlying the proposed project are summarized in Table 2.10-1. According to the United States Department of Agriculture (USDA) Soil Conservation Service, soil corrosion potential in the area of the project limits are considered generally high when exposed to uncoated steel, and generally low to moderate when exposed to concrete.[1]

2.10.2.4 Groundwater Conditions

Groundwater data and information along the project alignment is sparse. According to groundwater depth and elevation data for the bridge Log of Test Borings (LOTBs), elevation of groundwater was recorded as shallow as 17.7 ft bgs and as deep as 222 ft bgs.

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[1] United States Department of Agriculture Soil Conservation Service, 1978, Soils in Orange and the Western Part of Riverside Counties, California.

Table 2.10-1 Soil Types Within the Study Area

Location	Soil Types
Avenida Pico Undercrossing (UC) Bridge No. 55-0207	**Artificial fill** – silt, very fine sand, silty sand, fine to medium sand, buried concrete, silty clay, and sand with some gravel **Artificial fill and sub-base** – fine, loose sands **Terrace deposits** – fat clay with some gypsum crystals **Alluvium (undifferentiated) –** clayey silt, interbedded clay and fine sand, very fine silty sand to sandy silt with gypsum seams, gypsiferous silt, hard, silty clay and clayey silt, fat clay, and rounded gravel **Capistrano Formation** – sandy siltstone, clayey siltstone, weathered siltstone, and fresh siltstone
I-5/Avenida Pico Cut Slope	**Landslide debris** – sandy, clayey silt, stiff silt, sheared siltstone with minor amounts of rounded volcanic pebbles, sandy silt with some cemented zones and gypsum crystals, and sheared sandstone **Capistrano Formation** – silty sandstone to sandy siltstone, and blocky to massive gypsum crystals
I-5/Avenida Pico Cut Slope	**Artificial fill** – silt, very fine sand, silty sand, fine to medium sand, buried concrete, silty clay, sand with some gravel, poorly graded gravel, lean clay with sand, and silt with clay **Landslide debris** – sheared siltstone with caliche zones and gypsum seams, sandy silt with some sand beds, calcite stringers and gypsum crystals, fine grained sandy silt with some gypsum crystals, clayey silt **Colluvium** – silty clay to clayey silt **Terrace deposits** – fat clay with some gypsum crystals, silty sand with gravel **Alluvium (undifferentiated)** – silty clay **Capistrano Formation** – siltstone, sandy siltstone, clayey siltstone, and silty claystone
Avenida Vaquero UC Bridge No. 55-0223	**Artificial fill** – clayey silt, and silt to sandy silt **Terrace deposits** – sandy silt, gravelly sand, silty sand, and interbedded silt and sand with shell fragments **Capistrano Formation** – interbedded shale and clayey siltstone
Camino de Estrella Overcrossing (OC) Bridge No. 55-0224	**Artificial fill** – very fine clayey sand **Terrace deposits** – medium sand with gravel
Via California OC Bridge No. 55-0225	**Artificial fill** – sand and silty sand **Terrace deposits** – gravelly sand with cobbles and boulders, interbedded fine sand and silty sand, clayey silt with sandy gravel, interbedded sandy silt to silty fine sand, siltstone, and clay

Table 2.10-1 Soil Types Within the Study Area

Location	Soil Types
Camino Capistrano on-ramp UC Bridge No. 55-0227	**Artificial fill** – sandy silt **Alluvium** – sandy to clayey silt, fine sand to clean sand, gravel, interbedded sand and silt, silty sand, sandy silt to fine sand, interbedded silt and sand **Landslide debris** – translated Capistrano Formation siltstone
San Juan Creek Road UC Bridge No. 55-0298	**Artificial fill** – silty sand with abundant fine gravel, and clayey silt to silty clay with sand **Alluvium** – coarse sand **Landslide debris** – translated Capistrano Formation sandy siltstone to clayey siltstone, and translated Capistrano Formation siltstone

Source: Preliminary Geotechnical Report, Kleinfelder, Inc., April 2010 (Revised June 2010)

Fluctuations of the groundwater level, localized zones of perched water, and variations in soil moisture content should be anticipated during the following rainy season (late fall to early spring). Irrigation of landscaped areas on and adjacent to the site can also cause a fluctuation of local groundwater levels.

2.10.2.5 Regional Faulting, Seismicity and Surface Fault Rupture

The faults that are considered active and located in close proximity to the study area include the Newport Inglewood-Rose Canyon Fault and the San Joaquin Hills Blind Thrust Fault. The closest mapped active fault is located 3.1 mi from the study area. No Earthquake Fault-Rupture Hazard Zones delineated by the State of California are reported to be present in the area. Therefore, the threat of surface fault rupture during an earthquake is considered very low.

The Newport Inglewood-Rose Canyon Fault is a right-lateral strike-slip fault and a major structural feature within the study area. The Newport Inglewood-Rose Canyon Fault is comprised of several segments with similar trend. The nearest segment of the Newport Inglewood-Rose Canyon Fault, which is referred to as the “Dana Point section,” is anywhere from 3 to 4.5 mi to the southwest of the I-5 corridor. The Newport Inglewood-Rose Canyon Fault is capable of generating a magnitude 6.0–7.5 earthquake and has an estimated slip rate of 0.5–2.0 millimeters (mm) per year.

The San Joaquin Hills Blind Thrust Fault is a southwest-dipping, low-angle reverse (thrust) fault that is concealed and does not reach the ground surface. At its closest location near the northern terminus of the project alignment, this fault is approximately 7.3 mi to the north. The San Joaquin Blind Thrust Fault is capable of generating a magnitude 6.6 earthquake.

2.10.2.6 Landslides and Slope Instability

There are several landslides mapped in the study area, with the majority of these occurring as bedrock failures within the highly landslide-susceptible Capistrano Formation. Landslides are more concentrated within drainages where active erosion occurs, and generally within slopes comprised of Capistrano Formation that are adversely oriented with respect to bedding or weak discontinuities within the rock mass. Several slopes within the project alignment are within earthquake-induced landslide hazard zones. In general, slopes within the Capistrano Formation and where the bedding orientation is adverse are highly susceptible to earthquake-induced landslide.

Several cut slopes are required for the proposed improvements along I-5. The proposed cut slopes along the project alignment have a maximum slope of 2:1 (H:V). The height of the proposed cut slopes are typically less than 20 ft. However, proposed cut slopes located in a few areas of the project limits are as high as 60 ft.

2.10.2.7 Erosion

Construction of the proposed project will likely result in the alteration of existing landforms through grading activities. Alterations in landform from grading may cause substantial erosion and sedimentation impacts. Erosion and sedimentation in natural drainages and along natural slopes may also impact the various project elements. Applying standard engineering techniques during design and construction to prevent erosion will minimize these impacts. Typical erosion control minimization measures include improved drainage control and implementation of landscaping after construction.

2.10.2.8 Liquefaction and Seismic Compaction

When a loose, saturated granular deposit experiences seismic loading without substantial dispersion of excess pore water pressure, the deposit may liquefy and lose its strength. The potential impacts of liquefaction to the site may include:

- Settlement of ground surface
- Additional down drag forces on foundation piles as a result of soils settlement above the liquefied layers

- Reduction of shear strength of the liquefied soil resulting in reduced load carrying capacity. Liquefaction below areas of sloping ground may also lead to lateral slope instability (lateral spreading).

According to a Seismic Hazard Zones map prepared by the California Geological Survey for the Dana Point and San Clemente quadrangles (California Geological Survey, 2001a and 2002b), portions of the project alignment located in the alluvium-filled drainages of Segunda Deshecha Cañada, Prima Deshecha Cañada, and San Juan Creek are located in designated liquefaction hazard zones.

The potential for lateral spreading is not anticipated to be an issue due to relatively flat topography in areas of shallow groundwater, except along the I-5 alignment in the vicinity of where the roadway transitions from San Juan Creek to the Coastal Plain from approximately 100 ft to 2,500 ft west of the PCH UC.

Seismic compaction or settlement is a phenomenon in which loose, unsaturated sands tend to settle or densify during strong earthquake shaking. Sediments that are sufficiently loose are subject to such densification, which can cause ground surface settlement and damage to the surface and near-surface structures.

Preliminary estimates for liquefaction and seismic compaction at several bridge locations are presented in SPGRs. Settlements of pavements and retaining walls associated with this project should be expected following a substantial seismic event.

2.10.2.9 Tsunami and Seiche Potential

Tsunamis are seismically induced sea waves generated by offshore earthquake, submarine landslide, or volcanic activity. According to Figure 13-1 in the Natural Hazards Element of the City of San Clemente General Plan, the proposal project is not located within a Potential Tsunami Hazard Area. In addition, according to the City of Dana Point Public Safety Element, great magnitude waves have not historically been recorded near the City of Dana Point because the coastline is somewhat protected from the north by the coastal configuration and offshore islands. In a rare event, a tsunami could occur from south of the proposed project. However, based on the location of the proposed project (approximately 0.3 mi east of the Pacific Ocean at an approximate elevation of 98 ft amsl) and according to the City of San Clemente's General Plan (Section 13.0, Natural Hazards, Figure 13-1), the proposed project is not in a potential tsunami hazard area.

Seiches are another type of water-related seismically induced hazard. Seiches are extensive wave actions on lakes or reservoirs. Since no major lakes or open water areas exist in the Cites of Dana Point, San Juan Capistrano, and San Clemente, the potential for a seiche is remote.

2.10.3 Environmental Consequences

2.10.3.1 Temporary Impacts

Alternative 1 – No Build Alternative

No improvements would be made under the No Build Alternative. Therefore, the No Build Alternative would result in no short-term/temporary impacts to geological, mineral, or soil resources.

Build Alternatives 2 and 4 – Design Options A and B

A temporary increase in erosion may occur during construction. As discussed in Section 2.9, Water Quality and Stormwater Runoff, with implementation of erosion control BMPs as discussed in measure WQ-1, no potential adverse direct or indirect short-term/temporary water quality impacts would occur.

2.10.3.2 Permanent Impacts

Alternative 1 – No Build Alternative

The No Build Alternative does not involve any construction activities and would not alter existing geologic or soil conditions; therefore, it would not result in any adverse impacts to geological, mineral, or soil resources.

Build Alternatives 2 and 4 – Design Options A and B

The proposed project is expected to have minimal impact on geologic and topographic conditions with incorporation of the final design recommendations of the Final GDR. The primary geologic and geotechnical constraints affecting the design and construction of any of the Build Alternatives include:

- Seismic Hazards
- Landslides and Slope Instability
- Liquefaction
- Corrosion

Seismic Hazards

According to the City of San Clemente General Plan, Section 13.0, Natural Hazards, Build Alternatives 2 and 4 would not increase exposure to geologic hazards such as tsunami or seiche due to the distance from an enclosed body of water or the coastline.

In addition, no Earthquake Fault-Rupture Hazard Zones delineated by the State of California are reported to be present in the project limits. No known fault crosses the project limits. The closest mapped active fault is located 3.1 mi from the project limits. Therefore, the potential for surface fault rupture hazard within the project limits due to primary movement along a known fault is considered low. However, the Department considers the possibility of seismic activity and includes standard design features to minimize and avoid potential adverse impacts from seismic events. Implementation of Department standard seismic design features will ensure that no adverse direct or indirect permanent impacts from seismic hazards would occur under either Build Alternative 2 or 4 (under Design Options A and B).

Landslides and Slope Instability

As stated previously, under both Build Alternatives, several slopes within the project alignment are located within earthquake-induced landslide hazard zones. A site-specific Final GDR, Structure Foundation Reports (SFRs), and Materials Reports (MRs) will include subsurface exploration and laboratory testing during the design phase of the proposed project to further evaluate the potential earthquake-induced landslide hazard and to characterize the geotechnical conditions at these locations for use in further detailed analyses and slope design. Implementation of measures recommended by the Final GDR, SFRs, and MRs will ensure that no direct or indirect permanent adverse impacts from landslides or slope instability would occur under either Build Alternative 2 or 4 (under Design Options A and B).

Liquefaction

The proposed project is located in an area that may be subject to liquefaction. Potential impacts due to liquefaction and seismic compaction can be reduced through proper project planning, design, and construction. During the final design phase, a site-specific Final GDR will be prepared. The Final GDR will provide detailed analyses for the various design features, including but not limited to retaining walls and a noise barrier. The GDR will also provide soil sampling test results and geotechnical analysis regarding liquefaction, lateral spreading susceptibility, and final slope stability analyses. Based on the results of the Final GDR, the project design will include deepening the foundation and/or increasing the depth of piles or other suitable remedies. In addition, fill slopes will be stabilized by utilizing the 2:1 (H:V) slope, assuming no liquefaction and lateral spreading. Implementation of measures recommended by the Final GDR, SFRs, and MRs will ensure that no adverse direct or indirect permanent impacts from liquefaction would occur under either Build Alternative 2 or 4 (under Design Options A and B).

Corrosion

Although the corrosion potential to concrete for soils located within the project limits have been classified by the USDA Soil Conservation Service as low to medium for concrete materials, the corrosion potential of soils within the study area for uncoated steel is classified as high. Corrosion potential will be verified by field sampling and laboratory testing and will be provided in the Final GDR. Implementation of measures recommended by the Final GDR will ensure that no adverse direct or indirect permanent impacts from corrosion would occur under either Build Alternative 2 or 4 (under Design Options A and B).

2.10.4 Avoidance, Minimization, and/or Mitigation Measures

GEO-1 During final design, the Department shall prepare a Final GDR, SFRs, and MRs for the proposed project. The Final GDR, SFRs, and MRs will be written after detailed site sampling and testing and will include design recommendations and hazard minimization recommendations. The recommendations of the Final GDR, SFRs, and MRs shall be incorporated into the final design for the proposed project. The Final GDR, SFRs, and MRs will minimize potential impacts to the project related to corrosive soils, seismic hazards, landslides, liquefaction and slope instability.